

X-ray fluorescence microprobe analysis of 3 ω damaged fused silica optics

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We have employed the x-ray fluorescence microprobe beamline 10.3.1 at the ALS and performed a series of 1D and 2D elemental mappings on 3 ω damaged fused silica with a spatial resolution of 2 μm x 2 μm on sample and with a sensitivity down to 10 fg/ μm^2 .

Fig. 1 shows the x-ray microprobe data obtained for a 3 ω damaged crater (~300 μm diameter) in a fused silica optic. X-ray fluorescence spectra were collected over a 600 μm segment in 5 μm steps, starting from the undamaged area, across the crater and out to the undamaged area again. At each location, an integration time of 20s was used to collect the spectrum. The laser parameters used were: 35 J/cm², 7.6 ns pulse width, 1 pulse, and 0.98 mm beam diameter on sample. Fig. 1(a) is an accumulated spectrum of all 120 scans. Al and Si are intrinsic to the silica optic sample, and Ar from the ambient (air). Fe and Ni are from the beam pipe hardware (stainless steel), the presence of which was also detected in a background scan with no silica sample in the beam. The line profiles of the detected elements are plotted in Fig. 1(b). All elements except Ca exhibit a uniform profile. Ca shows peaks in three locations, 2 near the crater edge and 1 inside the crater. Similar data were obtained for a line scan in the undamaged area adjacent to the damaged crater.

A 2D scan of the same damage crater, 5 μm steps, 61 x 61 pixels, each integrated for 10 s is shown in Fig. 2. The mapped area covered approximately a quadrant of the crater. Fig. 2(a) shows an accumulated spectrum of all 3721 scans and the Fig. 2(b) shows the 2D profile of the detected elements. Again, Ca exhibit peaks in a couple of locations. The vertical “drops” in these profiles were due to beam dumps (every 4-6 hr) of the ALS storage ring.

The sensitivity of the ALS microprobe was determined to be ~10 fg/mm² as obtained by scanning (same integration time of 20s) a NIST standard consisting of the following elements in $\mu\text{g}/\text{cm}^2$: Si (29.1), K (16.5), Ti (12.6), Fe (14.2) and Zn (3.9), since 1 $\mu\text{g}/\text{cm}^2$ is equivalent to 10 fg/ μm^2 .

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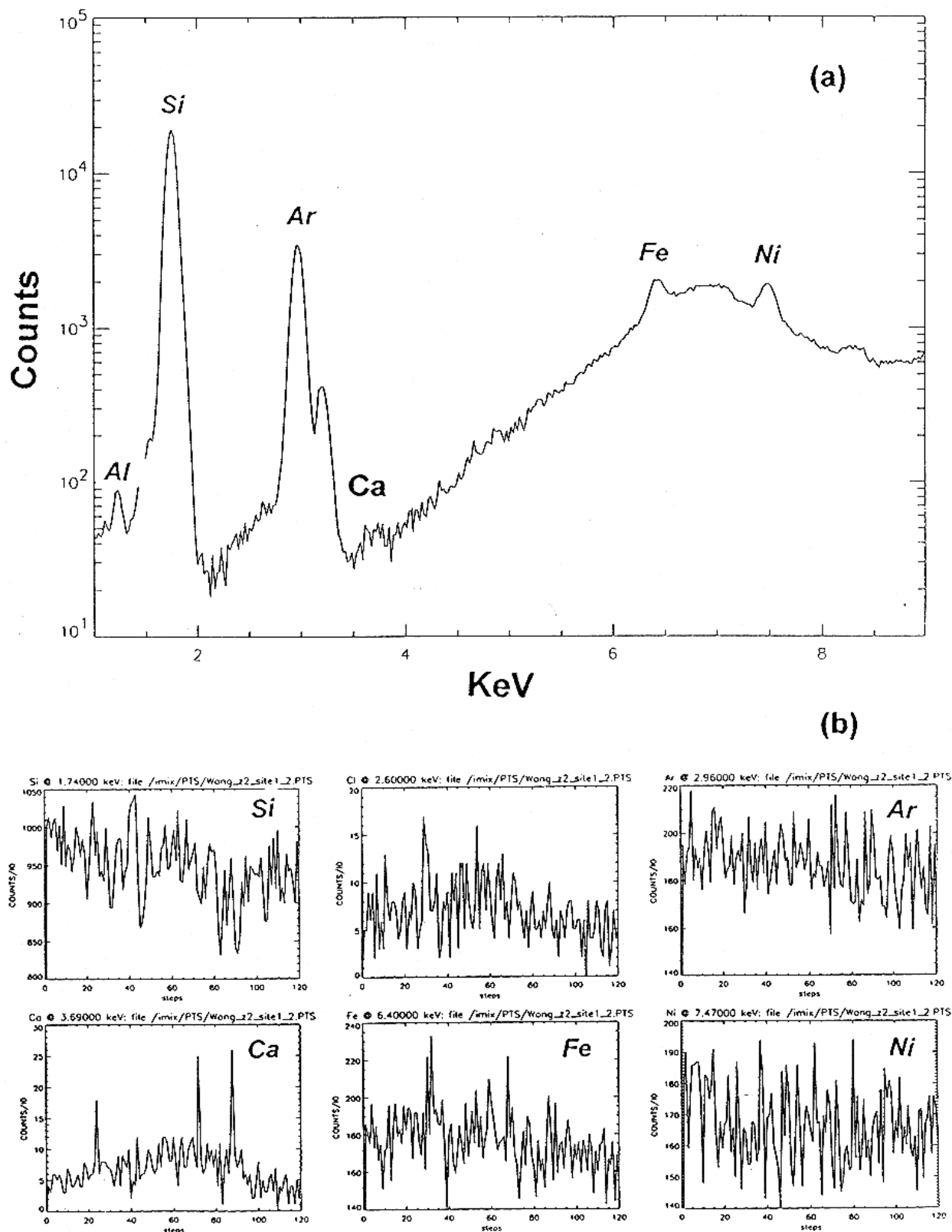


Fig. 1 (a) X-ray fluorescence spectra and (b) 1D chemical profiles in 3 σ damaged area of a fused silica optic: 5 mm step, 120 pixels, each integrated at 20s.

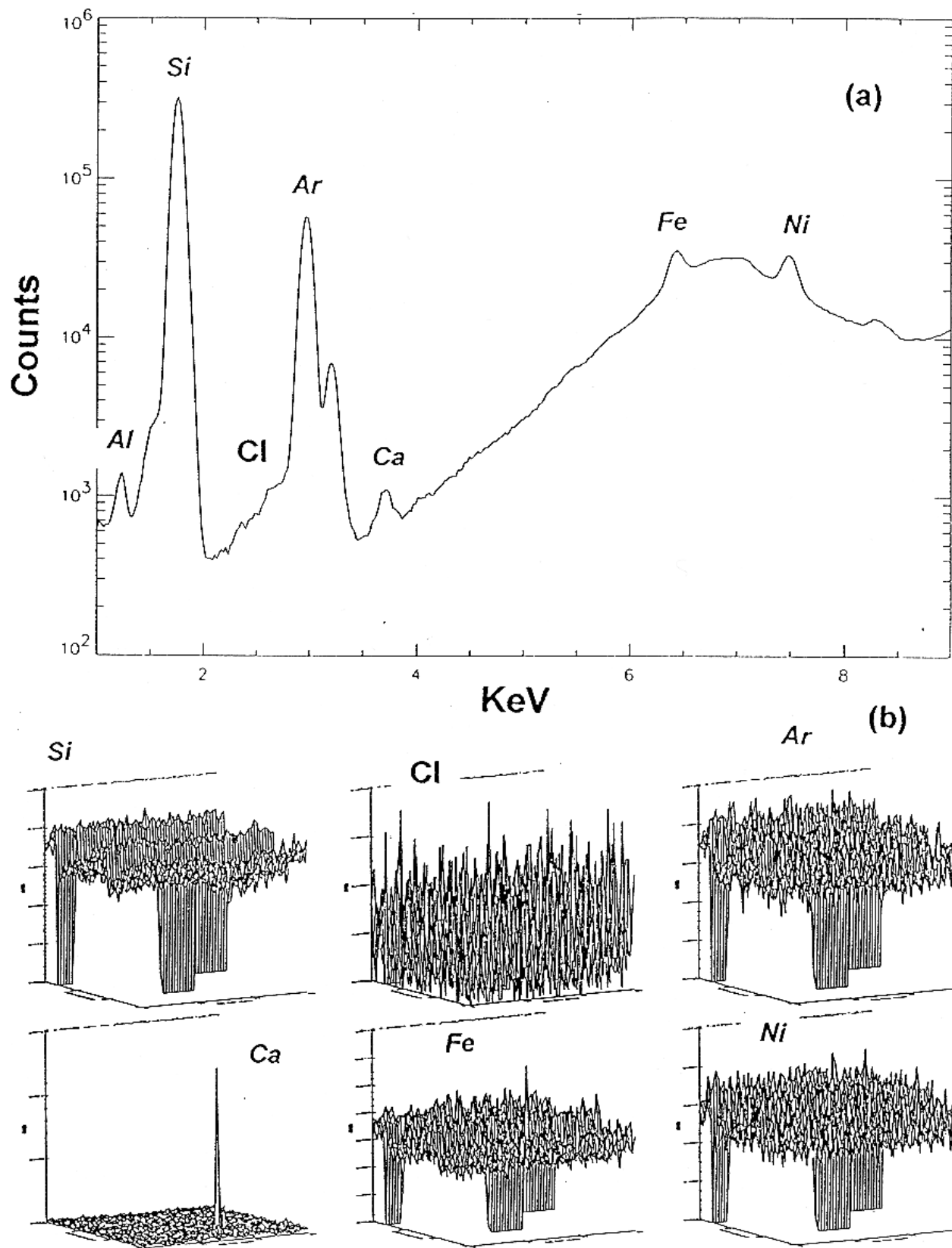


Fig. 2 (a) X-ray fluorescence spectra and (b) 2D chemical profiles in 3 ω damaged area of a fused silica optic: 5 mm step, 61 x 61 pixels, each integrated at 10s.